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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/043,225	01/14/2002	Masamoto Tago	Q67964	4956

23373 7590 07/08/2003

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EXAMINER

PAREKH, NITIN

ART UNIT PAPER NUMBER

2811

DATE MAILED: 07/08/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

**Office Action Summary**

Application No.

10/043,22

Applicant(s)

TAGO ET AL.

Examiner

Nitin Parekh

Art Unit

2811

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1) ☒ Responsive to communication(s) filed on 21 April 2003.
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 4) ☒ Claim(s) 1-158 is/are pending in the application.
- 4a) Of the above claim(s) 57-157 is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-56 and 158 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 21 April 2003 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on \_\_\_\_\_ is: a) ☐ approved b) ☐ disapproved by the Examiner.  
If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

**Priority under 35 U.S.C. §§ 119 and 120**

- 13) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).  
a) ☒ All b) ☐ Some \* c) ☐ None of:  
1. ☒ Certified copies of the priority documents have been received.  
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.  
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).  
\* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).  
a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

**Attachment(s)**

- 1) ☒ Notice of References Cited (PTO-892) 4) ☐ Interview Summary (PTO-413) Paper No(s). \_\_\_\_\_
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 5) ☐ Notice of Informal Patent Application (PTO-152)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 4. 6) ☐ Other: \_\_\_\_\_

## **DETAILED ACTION**

### ***Election/Restriction***

1. Applicant's election of Group I, claims 1-56 and 158 in Paper No. 6 is acknowledged. Because applicant did not distinctly and specifically point out the supposed errors in the restriction requirement, the election has been treated as an election without traverse (MPEP § 818.03(a)).

### **Oath/Declaration**

2. The oath/declaration filed on 01/14/02 is acceptable.

### ***Drawings***

3. The formal drawings filed on 01/14/02 are acceptable.

### ***Information Disclosure Statement***

4. The Information Disclosure Statement filed on 03/06/02 has been considered.

### ***Claim Rejections - 35 USC § 103***

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

6. Claims 1, 3, 5, 7, 9, 11, 21, 22, 25, 26, 29-33, 39-43, 49, 50, 53 and 54 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046) in view of Chan et al. (US Pat. 5471092).

Regarding claim 1, Marlin discloses a semiconductor device (100 in Fig. 5) having a solder bump (310 in Fig. 5) formed of an alloy solder including tin-silver (SnAg- Col. 2, line 19), the Sn and Ag being a first and second main components of the alloy respectively on a underbump metallurgy (UBM) structure on a wiring/power layer (104 in Fig. 5), the device further comprising:

- the UBM structure comprising a copper layer/solder support layer (308 in Fig. 5; Col. 2, line 60), an underbump layer (UBL-304 in Fig. 5; Col. 2, line 33) having nickel as the first metal and a contact layer/electrically conductive nonwetable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5; Col. 2, line 30), and
- a final structure having the solder ball/reflowed solder ball (310 in Fig. 6) being formed on the wiring/power layer

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an intermetallic compound being formed between the solder bump and the UBL, the intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the main component.

Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder having tin as a main component on a metal/solder reactive layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 20-56) to prevent formation of the intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56), the intermetallic compound/Cu-Sn including the main component/metal (Sn) of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder (Col. 3-6).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate an intermetallic compound being formed between the solder bump and the UBL, the intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the main component as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 5, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 1 above, wherein Martin further teaches the tin being the main component of the SnAg alloy solder (Col. 2, line 19).

Regarding claim 9, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 5 above, wherein Martin further teaches silver being the second main component of the alloy solder after tin (Col. 2, line 19).

Regarding claims 21 and 22, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 1 above, except the second metal, which is different from the first metal is allowed to form an intermetallic compound with tin and copper.

Chan et al. further teach the intermetallic compound (Sn-Cu) being formed/allowed to be formed with Sn and the second metal such as Cu (Col. 3, lines 10-56), which is different from the first metal such as nickel.

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a second metal being allowed to form an intermetallic compound with tin where second metal different from the first metal as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 29, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 1 above, wherein Martin further teaches the first metal in the UBL being nickel (304 in Fig. 5; Col. 2, line 33).

Regarding claim 30, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 29 above, except the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities.

Chan et al. further teach using a Ni layer/alloy (42 in Fig. 3) as an UBL where the layer/alloy is selected to include Ni, nickel-phosphorous (NiP) having different film qualities or the combination/lamination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 31, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 29 above, except the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include one or more layers/lamination of material such as Ni, Cu, NiP alloy, etc. (Col. 4, line 31) to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claims 32 and 33, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 29-31 above, except the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, NiP or the combination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.



Regarding claim 49, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 1 above, wherein Martin further teaches the contact layer/electrically conductive nonwetable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5 and 6) being provided between the wiring/power layer and the UBL (Col. 2, line 30).

Regarding claim 50, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 49 above, wherein Martin further teaches the contact/electrically conductive nonwetable layer being TiW alloy (302 in Fig. 5 and 6; Col. 2, line 30).

A. Regarding claim 3, Marlin discloses a semiconductor device (100 in Fig. 5) having solder bump (310 in Fig. 5) formed of an alloy solder including tin-silver (SnAg- Col. 2, line 19), the Sn and Ag being a first and second main components of the alloy respectively on a underbump metallurgy (UBM) structure on a wiring/power layer (104 in Fig. 5), the device further comprising:

- the UBM structure comprising a copper layer/solder support layer (308 in Fig. 5; Col. 2, line 60), an underbump layer (UBL-304 in Fig. 5; Col. 2, line 33) having
- nickel as the first metal and a contact layer/electrically conductive nonwetable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5; Col. 2, line 30), and

- a final structure having the solder ball/reflowed solder ball (310 in Fig. 6) being formed on the wiring/power layer

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an intermetallic compound being formed between the solder bump and the UBL, the intermetallic compound including a metal that is a main component of the alloy solder and a second metal.

Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder having tin as a main component on a metal/solder reactive layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 20-56) to prevent formation of the intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56), the intermetallic compound/Cu-Sn including the main component/metal (Sn) of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder (Col. 3-6).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate an intermetallic compound being formed between the solder bump and the UBL, the intermetallic compound including a metal that is a main component of the alloy solder and a second metal as taught by Chan et al. so that

the formation of the intermetallics in the underlying layers can be prevented further diffusion of the intermetallic compound can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

**B.** Regarding claim 3, temporarily arranging a second metal layer on the underbump layer and then dissolving into the alloy solder on formation of the solder bump do not distinguish over Marlin and Chan et al., because only the final product/structure is relevant, not the process of making such as "temporarily arranging and dissolving" or "laminating and hot pressing or fusing". Note that a "product by process" claim is directed to the product per se, no matter how actually made, *In re Hirao*, 190 USPQ 15 at 17 (footnote 3). See also *In re Brown*, 173 USPQ 685; *In re Luck*, 177 USPQ 523; *In re Fessmann*, 180 USPQ 324; *In re Avery*, 186 USPQ 161; *In re Wertheim*, 191 USPQ 90 (209 USPQ 554 does not deal with this issue); and *In re Marrosi et al.*, 218 USPQ 289, all of which make it clear that it is the patentability of the final product per se which must be determined in a "product by process" claim, and not the patentability of the process, and that an old or obvious product produced by a new method is not patentable as a product, whether claimed in "product by process" claims or not. Note that applicant has the burden of proof in such cases, as the above case law makes clear. See also MPEP 706.03(e).

Regarding claim 7, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 3 above, wherein Martin further teaches the tin being the main component of the SnAg alloy solder (Col. 2, line 19).

Regarding claim 11, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 7 above, wherein Martin further teaches silver being the second main component of the alloy solder after tin (Col. 2, line 19).

Regarding claims 25 and 26, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 3 above, except the second metal, which is different from the first metal is allowed to form an intermetallic compound with tin.

Chan et al. further teach the intermetallic compound (Sn-Cu) being formed/allowed to be formed with Sn and the second metal such as Cu, which is different from the first metal such as nickel (Col. 3, lines 10-56).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a second metal being allowed to form an intermetallic compound with tin where second metal different from the first metal as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 39, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 3 above, wherein Martin further teaches the first metal in the UBL being nickel (304 in Fig. 5; Col. 2, line 33).

Regarding claim 40, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 39 above, except the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, nickel-phosphorous (NiP) having different film qualities or the combination/lamination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 41, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 39 above, except the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include one or more layers/lamination of material such as Ni, Cu, NiP alloy, etc. (Col. 4, line 31) to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claims 42 and 43, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 39-41 above, except the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, NiP or the combination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy as taught by Chan et al. so that the formation of the intermetallics in the

underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 53, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 3 above, wherein Martin further teaches the contact layer/electrically conductive nonwetable layer of titanium-Tungsten (TiW) alloy (302 in Fig. 5 and 6) being provided between the wiring/power layer and the UBL (Col. 2, line 30).

Regarding claim 54, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 53 above, wherein Martin further teaches the contact/electrically conductive nonwetable layer being TiW alloy (302 in Fig. 5 and 6; Col. 2, line 30).

Regarding claim 158, Marlin discloses a semiconductor device (100 in Fig. 5 and 6) having an electrode structure comprising:

- a solder bump (310 in Fig. 5), and
- a underbump metallurgy (UBM) structure having a plurality of metal layers including an underbump layer (UBL-304 in Fig. 5; Col. 2, line 33)

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an intermetallic compound being formed between the solder bump and the UBL

Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder on underlying metal/phased layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 10-30) to prevent formation of the intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56; Col. 3-6).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate an intermetallic compound being formed between the solder bump and the UBL as taught by Chan et al. so that formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's electrode structure.

7. Claims 2, 4, 6, 8, 10, 12, 23, 24, 27, 28, 34-38, 44-48, 51, 52, 55 and 56 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046) in view of Chan et al. (US Pat. 5471092) and Darveaux et al. (US Pat. 6201305).

Regarding claim 2, Marlin discloses a semiconductor device (100 in Fig. 5) having a solder bump (310 in Fig. 5) formed of an alloy solder including tin-silver (SnAg- Col. 2, line 19), the Sn and Ag being a first and second main components of the alloy



respectively on a underbump metallurgy (UBM) structure on a wiring/power layer (104 in Fig. 5), the device further comprising:

- the UBM structure comprising a copper layer/solder support layer (308 in Fig. 5; Col. 2, line 60), an underbump layer (UBL-304 in Fig. 5; Col. 2, line 33) having nickel as the first metal and a contact layer/electrically conductive nonwetable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5; Col. 2, line 30), and
- a final structure having the solder ball/reflowed solder ball (310 in Fig. 6) being formed on the wiring/power layer

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an alloy layer composed of a combination of intermetallic compound being formed between the solder bump and the UBL, the combination including:

- a) an intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the main component, and
- b) an intermetallic compound of the first metal included in the UBL and the metal that is the main component of the alloy solder.

a) Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder having tin as a main component on a metal/solder reactive layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines

20-56) to prevent formation of the intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56), the intermetallic compound/Cu-Sn including the main component/metal (Sn) of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder (Col. 3-6).

b) Darveaux et al. teach a solder ball mounting structure (Fig. 2A/2B) having underbump layer such as nickel on a laminated pad (28 in Fig. 2A/2B; Col. 3, line 57) where an intermetallic compound such as tin-nickel (SnNi) is formed, the intermetallic compound including the metal/first metal such as nickel and the main component of the alloy of the solder ball such as tin (Col. 3, line 55- Col. 4, line 7).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a combination of intermetallic compound being formed between the solder bump and the UBL, the combination including an intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the main component and an intermetallic compound of the first metal included in the UBL and the metal that is the main component of the alloy solder as taught by Chan et al. and Darveaux et al. so that formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 6, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 2 above, wherein Martin further teaches the tin being the main component of the SnAg alloy solder (Col. 2, line 19).

Regarding claim 10, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 6 above, wherein Martin further teaches the silver being the second main component of the alloy solder after tin (Col. 2, line 19).

Regarding claims 23 and 24, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 2 above, except the second metal, which is different from the first metal is allowed to form an intermetallic compound with tin.

Chan et al. further teach the intermetallic compound (Sn-Cu) being formed/allowed to be formed with Sn and the second metal such as Cu, which is different from the first metal such as nickel (Col. 3, lines 10-56).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a second metal being allowed to form an intermetallic compound with tin where second metal different from the first metal as taught by Chan et al. so that formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 34, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 2 above, wherein Martin further teaches the first metal in the UBL being nickel (304 in Fig. 5; Col. 2, line 33).

Regarding claim 35, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 34 above, except the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, nickel-phosphorous (NiP) having different film qualities or the combination/lamination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 36, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 34 above, except the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include one or more layers/lamination of material such as Ni, Cu, NiP alloy, etc. (Col. 4, line 31) to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claims 37 and 38, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 34-36 above, except the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, NiP or the combination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi)

alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 51, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 2 above, wherein Martin further teaches the contact/electrically conductive nonwetable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5 and 6) being provided between the wiring/power layer and the UBL (Col. 2, line 30).

Regarding claim 52, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 51 above, wherein Martin further teaches the contact/electrically conductive nonwetable layer being TiW alloy (302 in Fig. 5 and 6; Col. 2, line 30).

**A.** Regarding claim 4, Marlin discloses a semiconductor device (100 in Fig. 5) having a solder bump (310 in Fig. 5) formed of an alloy solder including tin-silver (SnAg- Col. 2, line 19), the Sn and Ag being a first and second main components of the alloy respectively on a underbump metallurgy (UBM) structure on a wiring/power layer (104 in Fig. 5), the device further comprising:

Art Unit: 2811

- the UBM structure comprising a copper layer/solder support layer (308 in Fig. 5; Col. 2, line 60), an underbump layer (UBL-304 in Fig. 5; Col. 2, line 33) having
- nickel as the first metal and a contact layer/electrically conductive nonwetable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5; Col. 2, line 30), and
- a final structure having the solder ball/reflowed solder ball (310 in Fig. 6) being formed on the wiring/power layer

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an alloy layer composed of a combination of intermetallic compound being formed between the solder bump and the UBL, the combination including:

- a) an intermetallic compound including a metal that is a main component of the alloy solder and a second metal, and
- b) an intermetallic compound of the first metal included in the UBL and the metal that is the main component of the alloy solder.

a) Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder having tin as a main component on a metal/solder reactive layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 20-56) to prevent formation of the intermetallics in the underlying layers, improve

adhesion and to reduce the joint stress (Col. 3, line 10-56), the intermetallic compound/Cu-Sn including the main component/metal (Sn) of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder (Col. 3-6).

b) Darveaux et al. teach a solder ball mounting structure (Fig. 2A/2B) having underbump layer such as nickel on a laminated pad (28 in Fig. 2A/2B; Col. 3, line 57) where an intermetallic compound such as tin-nickel (SnNi) is formed, the intermetallic compound including the metal/first metal such as nickel and the main component of the alloy of the solder ball such as tin (Col. 3, line 55- Col. 4, line 7).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a combination of intermetallic compound being formed between the solder bump and the UBL, the combination including an intermetallic compound including a metal that is a main component of the alloy solder and a second metal and an intermetallic compound of the first metal included in the UBL and the metal that is the main component of the alloy solder as taught by Chan et al. and Darveaux et al. so that formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.



Art Unit: 2811

**B.** Regarding claim 4, temporarily arranging a second metal layer on the underbump layer and then dissolving into the alloy solder on formation of the solder bump do not distinguish over Marlin, Chan et al. and Darveaux et al., because only the final product/structure is relevant, not the process of making such as “temporarily arranging and dissolving” or “laminating and hot pressing or fusing”. Note that a “product by process” claim is directed to the product per se, no matter how actually made, In re Hirao, 190 USPQ 15 at 17 (footnote 3). See also In re Brown, 173 USPQ 685; In re Luck, 177 USPQ 523; In re Fessmann, 180 USPQ 324; In re Avery, 186 USPQ 161; In re Wertheim, 191 USPQ 90 (209 USPQ 554 does not deal with this issue); and In re Marrosi et al., 218 USPQ 289, all of which make it clear that it is the patentability of the final product per se which must be determined in a “product by process” claim, and not the patentability of the process, and that an old or obvious product produced by a new method is not patentable as a product, whether claimed in “product by process” claims or not. Note that applicant has the burden of proof in such cases, as the above case law makes clear. See also MPEP 706.03(e).

Regarding claim 8, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 4 above, wherein Martin further teaches the tin being the main component of the SnAg alloy solder (Col. 2, line 19).

Regarding claim 12, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 8 above, wherein Martin further teaches the silver being the second main component of the alloy solder after tin (Col. 2, line 19).

Regarding claims 27 and 28, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 4 above, except the second metal, which is different from the first metal is allowed to form an intermetallic compound with tin.

Chan et al. further teach the intermetallic compound (Sn-Cu) being formed/allowed to be formed with Sn and the second metal such as Cu, which is different from the first metal/nickel (Col. 3, lines 10-56).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a second metal being allowed to form an intermetallic compound with tin where second metal different from the first metal as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 44, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 4 above, wherein Martin further teaches the first metal in the UBL being nickel (304 in Fig. 5; Col. 2, line 33).

Regarding claim 45, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 44 above, except the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, nickel-phosphorous (NiP) having different film qualities or the combination/lamination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 46, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 44 above, except the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include one or more layers/lamination of material such as Ni, Cu, NiP alloy, etc. (Col. 4, line 31) to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claims 47 and 48, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 44-46 above, except the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, NiP or the combination of Ni and NiP to improve solderability : (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 55, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 4 above, wherein Martin further teaches the contact/electrically conductive nonwetable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5 and 6) being provided between the wiring/power layer and the UBL (Col. 2, line 30).

Regarding claim 56, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 55 above, wherein Martin further teaches the contact/electrically conductive nonwetable layer being TiW alloy (302 in Fig. 5 and 6; Col. 2, line 30).

8. Claims 13 and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046) and Chan et al. (US Pat. 5471092) as applied to claims 1, 5 and 9 above, and further in view of Andricacos et al. (US Pat. 6224690).

Regarding claims 13 and 17, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1, 5 and 9 above, except adding copper to the alloy solder.

Andricacos et al. teach using tin based solders having a variety of compositions including Sn-Ag solder having metals such as copper, nickel, etc. (see Table I, Col. 6)

being added to achieve the desired melting range and improved wetting/flow properties (Col. 5, line 65- Col. 6, line 50).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to add copper to the alloy solder as taught by Andricacos et al. so that the desired melting range can be achieved and the wetting/flow properties can be improved in Chan et al. and Marlin's solder bump device.

9. Claims 15 and 19 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046) and Chan et al. (US Pat. 5471092) as applied to claims 3, 7 and 11 above, and further in view of Andricacos et al. (US Pat. 6224690).

Regarding claims 15 and 19, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3, 7 and 11 above, except adding copper to the alloy solder.

Andricacos et al. teach using tin based solders having a variety of compositions including Sn-Ag solder having metals such as copper, nickel, etc. (see Table I; Col. 6) being added to achieve the desired melting range and improved wetting/flow properties (Col. 5, line 65- Col. 6, line 50).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to add copper to the alloy solder as taught by Andricacos et al. so

Art Unit: 2811

that the desired melting range can be achieved and the wetting/flow properties can be improved in Chan et al. and Marlin's solder bump device.

10. Claims 14 and 18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046), Chan et al. (US Pat. 5471092) and Darveaux et al. (US Pat. 6201305) as applied to claims 2, 6 and 10 above, and further in view of Andricacos et al. (US Pat. 6224690).

Regarding claims 14 and 18, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2, 6 and 10 above, except adding copper to the alloy solder.

Andricacos et al. teach using tin based solders having a variety of compositions including Sn-Ag solder having metals such as copper, nickel, etc. (see Table I, Col. 6) being added to achieve the desired melting range and improved wetting/flow properties (Col. 5, line 65- Col. 6, line 50).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to add copper to the alloy solder as taught by Andricacos et al. so that the desired melting range can be achieved and the wetting/flow properties can be improved in Darveaux et al., Chan et al. and Marlin's solder bump device.

11. Claims 16 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046), Chan et al. (US Pat. 5471092) and Darveaux et al. (US Pat. 6201305) as applied to claims 4, 8 and 12 above, and further in view of Andricacos et al. (US Pat. 6224690).

Regarding claims 16 and 20, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4, 8 and 12 above, except adding copper to the alloy solder.

Andricacos et al. teach using tin based solders having a variety of compositions including Sn-Ag solder having metals such as copper, nickel, etc. (see Table I, Col. 6) being added to achieve the desired melting range and improved wetting/flow properties (Col. 5, line 65- Col. 6, line 50).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to add copper to the alloy solder as taught by Andricacos et al. so that the desired melting range can be achieved and the wetting/flow properties can be improved in Darveaux et al., Chan et al. and Marlin's solder bump device.

### ***Conclusion***

12. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Reference D is cited as being related to tin-silver solder bump having underbump layers.



Any inquiry concerning this communication or earlier communications from the examiner should be directed to Nitin Parekh whose telephone number is 703-305-3410. The examiner can normally be reached on 09:00AM-05:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Tom Thomas can be reached on 703-308-2772. The fax phone numbers for the organization where this application or proceeding is assigned are 703-308-7722, 703-308-7724 or 703-872-9318 (Right FAX) for regular communications; 703-872-9310 (Right FAX) for After Final communications and 703-872-9310 (Right FAX) for customer service.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-306-3431.

NP

06-20-03

  
NITIN PAREKH  
PATENT EXAMINER

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